THE MAMMOTH "EARTHQUAKE FAULT" AND RELATED FEATURES IN MONO COUNTY, CALIFORNIA*

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IN UNDERTAKING this work it was our intention to investigate the well-known "Earthquake Fault" situated about two miles northwest of the town of Mammoth in Mono County, California. In working in the surrounding region we found, however, that this is only a part of an extensive system of similar features. The locations of those which have been found thus far are shown on the map (fig. 1), which is reproduced from U. S. Geological Survey topographical maps, Mount Lyell and Mount Morrison quadrangles. We consider that the southern and eastern limits of the features shown are real, whereas in the northern and western directions they represent only the extent of our investigations to date.

The maps are somewhat inaccurate with respect to physiographic features, and especially are obsolete with reference to roads, because the Mount Lyell Quadrangle (western part of fig. 1) is based on a survey made in 1898–99, and the Mount Morrison Quadrangle (surveyed in 1911–12) shows, in addition to roads existing at the time of the survey, roads and trails from information given by the Forest Service in 1934. Besides these changes, we have added in figure 1 a few important roads and landmarks not shown on the original maps. We have drafted the features under discussion, and these are designated by the letters A to J, while the numbers 1 to 14 refer to particular points of interest.

The features may be described as linear fractures in volcanic rock. Samples from points 10 (see fig. 9) and 12 of the map (fig. 1) have been identified by Dr. Ian Campbell as basalts, whereas samples from the region between points 1 and 2 (see figs. 2 and 3) are rhyolites. Near point 9 there is a region of platy rhyolite (see figs. 5 and 6).

Volcanic material appears in many places along the eastern edge of the Sierra block and in this region overlies older glaciated structures. The Inyo Crater group, of which the Inyo Crater Lakes are the southern end, have been investigated recently by E. B. Mayo, L. C. Conant, and J. R. Cheliowsky,[1] and W. C. Putnam[2] has studied the Mono Craters which form the northern continuation of the Inyo Crater group. To the south of the Inyo Crater Lakes, too, the volcanic rocks continue, as shown by the mountain marked "4" in figure 1, in the older Mammoth Mountain, and in cinder cones appearing several miles to the south and southwest on top of granitic mountains. Thus, the features

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[1] "Southern Extension of the Mono Craters, California." *Am. Jour. Science*, ser. 5, vol. 32, pp. 81–97 (1936).

[2] "The Mono Craters, California," *Geograph. Review*, 28; 68–82 (1932); more detailed in his unpublished thesis, California Institute of Technology, Dept. of Geology.

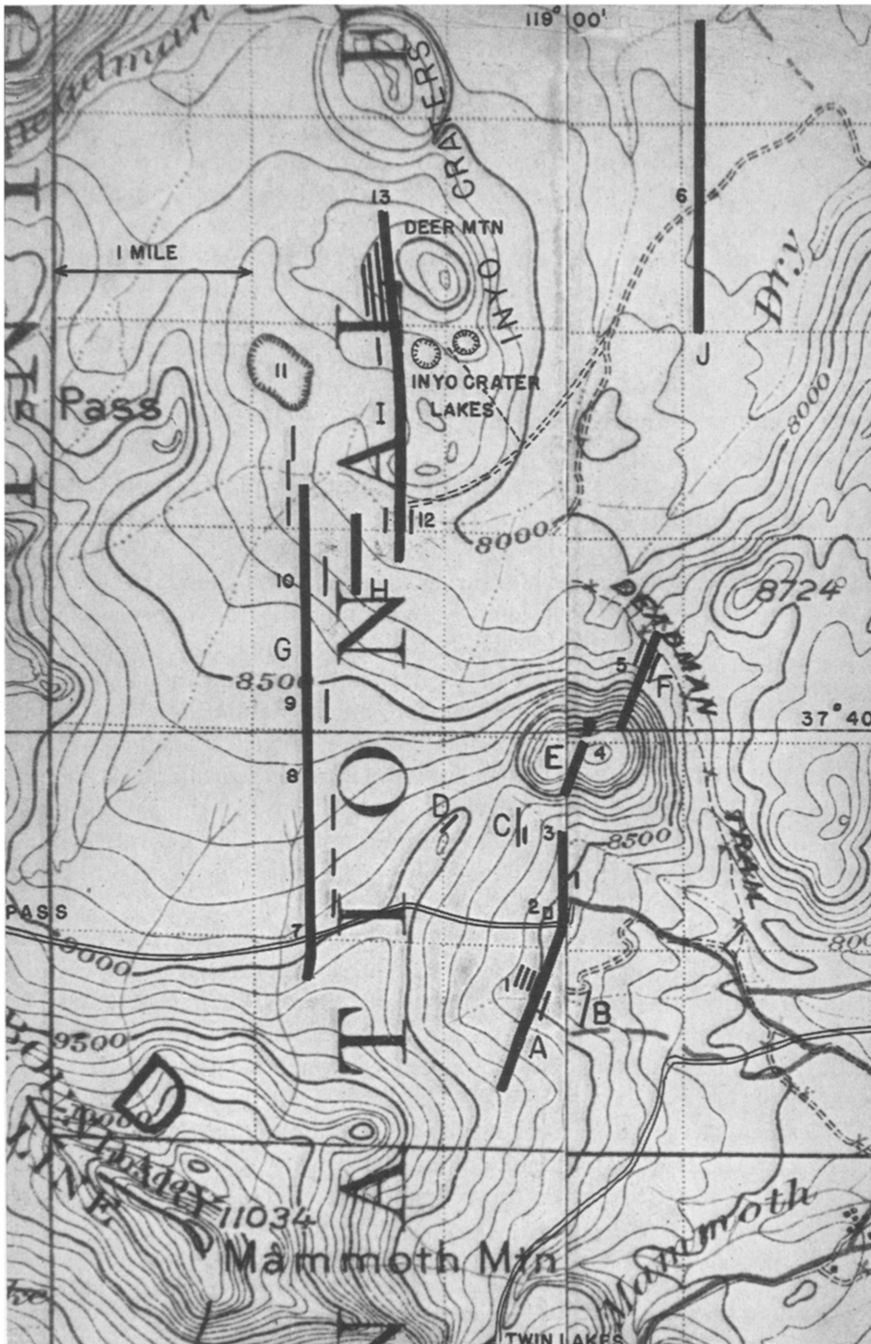
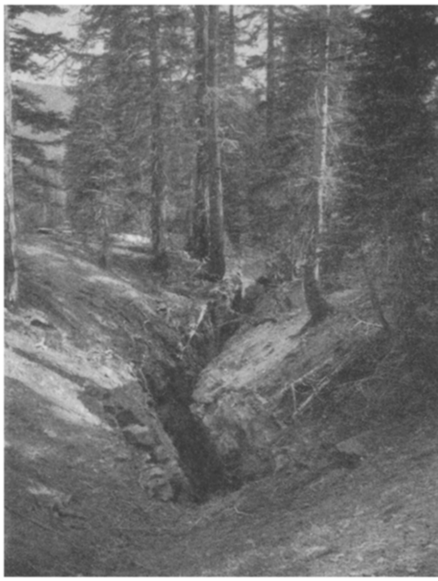


Fig. 1. Map of Mammoth region.




Figs. 2 and 3. "Earthquake Fault" near point 2 on map.

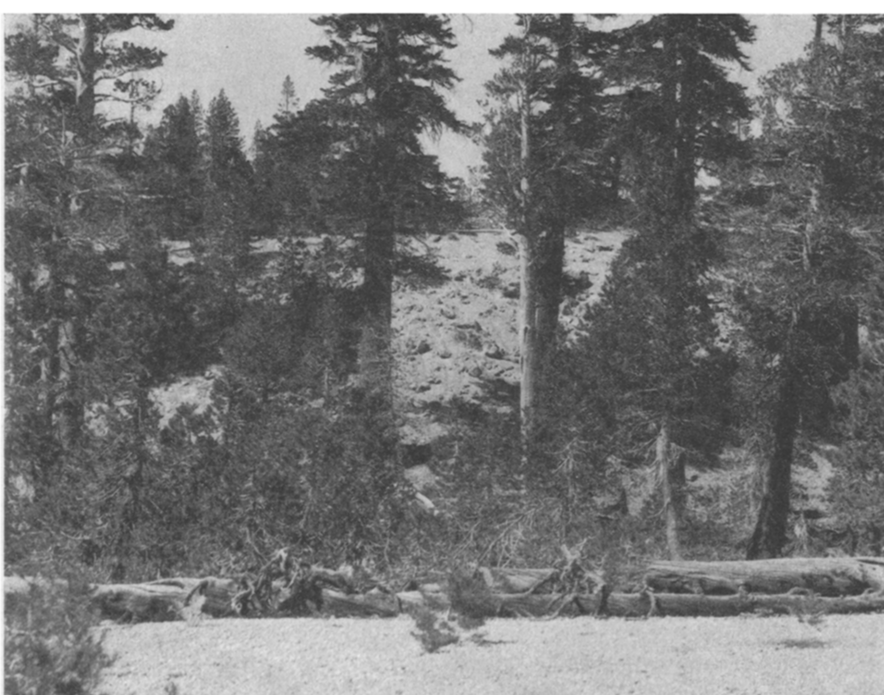


Fig. 4. Bluff near point 8 on map.

under investigation are parallel to and situated on a line of volcanic features extending for about thirty miles in a southerly direction from the volcanic islands in Mono Lake.

The well-known Mammoth "Earthquake Fault" is north and south of point 2, figure 1. It exhibits a large fracture (figs. 2 and 3) some seven feet in maximum width and approximately sixty feet deep, measured to the surface of the snow and débris (see fig. 3). The distances along this fracture (A in fig. 1) have been measured with tape, while all the other distances have been determined by pacing. The directions were determined by compass. We assumed a magnetic declination of 17° east. A number of points of each feature have been located by bearings taken on surrounding mountain peaks.

The extent of the "Earthquake Fault" north and south of the Mammoth–San Joaquin Valley road is shown on figure 1 (point 2 indicates the parking place). Between points 2 and 1 it is visible as a fracture in exposed rock and as a V-shaped trench in soil (fig. 2), mostly granular pumice. Near point 1 it cuts through an exposed rocky bluff which at this point is about seventy feet high and runs approximately east–west. Just north of this bluff the main trace is much reduced in width, and a number of narrow parallel cracks appear with depths to a maximum of seventy feet. Continuing to the south the main trace appears as a small V-trench, crossing several drainage features and alternate ridges, and disappears on the slope of Mammoth Mountain, ending abruptly in a large oval depression.

There are several smaller traces east of point 1, one of which (B in fig. 1) shows a deep crack, some seventy feet to the snow. A small brook flowing from west to east disappears in the small V-shaped trace shown just east of point 1 and does not appear again.

North of the road, between points 2 and 3, the "Earthquake Fault" appears essentially the same as the southern section; it ends with two large oval depressions at the slope of mountain "4," where it is lost in the thick rocky débris which covers the steep slope of the mountain. West of point 3 there are several minor traces; one of them, C, exhibits a very clean break in exposed rock. D, farther to the west, consists of a linear grouping of oval depressions.

The trace appears again on the top of mountain "4" in the form of V-shaped trenches and breaks in exposed rock. Another branch, F, continues northward; it finally was lost in a drainage area after traversing the slopes of several small valleys.

Another conspicuous rift, J, was found at point 6, where it crosses the road to the Inyo Crater Lakes. The larger part of it is clearly visible from the summit of Deer Mountain. At both ends it was lost in drainage areas. The region between F and J has not been investigated. There are some smaller rifts east of J.

The newly found feature G is the largest of those observed thus far in this region. Its southern limit appears abruptly on the slope of Mammoth Mountain, about seven hundred feet south of the Mammoth–San Joaquin River road (point 7). In this section it is a trench with the western side higher than the eastern. Between points 7 and 8 its nature changes, and at 8 it appears as a steep bluff on the west side, more than sixty feet high at the maximum (fig. 4). The feature is crossed by several streams flowing approximately eastward and forming cascades with little erosion in rock and deep cuts in pumice.

Near 9 the break is most spectacular (figs. 5 and 6). The photograph here shown as figure 7 was taken north of point 9. Halfway between 9 and 10 the trace is again a trench with the west side higher (fig. 8), continuing through exposed rock near point 10 (fig. 9). North of point 10 the trace becomes smaller and, after crossing several stream beds, is lost approaching the pumice flat (point 11), where it cannot be distinguished from drainage features. Secondary features appear east of G throughout its length; the largest is designated "H" in figure 1.

East of the section where G diminished in size another trace, I, appears. At point 12, where it terminates the extension of the road to the Inyo Crater Lakes, it has the form of a 45-foot bluff similar to the one shown in figure 4. It continues northward, forming mostly a deep trench with unequal sides, the western being always the higher. In the region west of Deer Mountain there is a complicated system of depressions west of the main trace which has been followed to point 13, where there is a pond. We have not been over the ground north of this point.

In general, the vertical displacements are such that in the eastern features (A, E, F, and J) the eastern side is displaced relatively upward whereas in the features G and I the west side is the higher. In G and I the maximum exceeds sixty feet (18 meters); the maximum does not exceed ten feet (3 m.) approximately in J, and three feet in F. In A (Mammoth "Earthquake Fault") the displacements have been accurately measured at a number of places in rock which could be identified in shape and texture as that which had been in contact before the break. The maximum measured relative elevation of the eastern side is 1½ feet (½ m.).

The horizontal displacement could only be found in fractures in exposed rock where corresponding points on the two sides could be accurately identified. In A the maximum observed displacement, normal to the fractured surface, is approximately seven feet (2 m.); at the same point the displacement parallel to the fracture surface is 1½ feet (45 cm.) with the east side relatively north. In G the maximum horizontal displacement normal to the fracture surface appears to exceed forty feet (12 m.), although the surfaces are fractured to such an extent that precise identification was not possible. In general, where the main feature becomes narrow it is accompanied by smaller parallel cracks, such as near point 1. Going north in the western group, the large displacement decreases near point 10 of G and appears to shift successively to H and I.

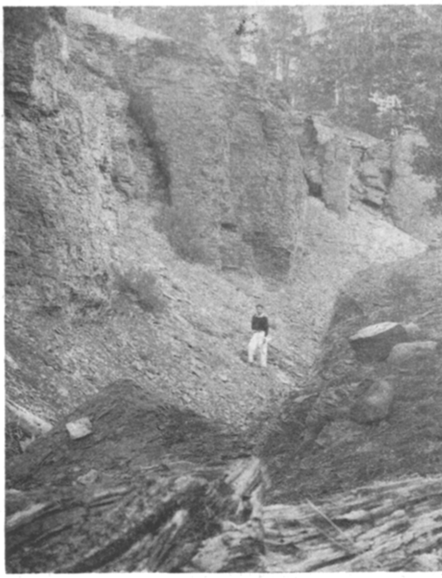


Fig. 5

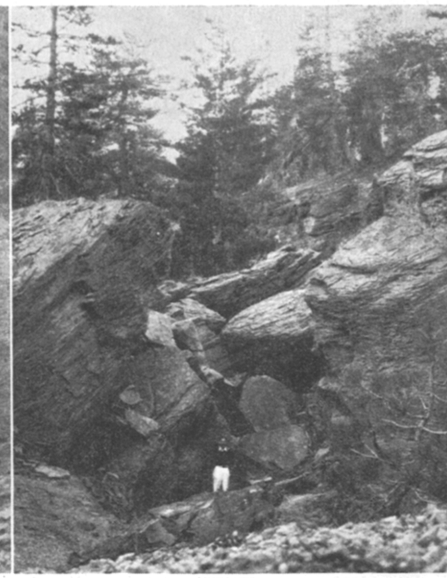


Fig. 6

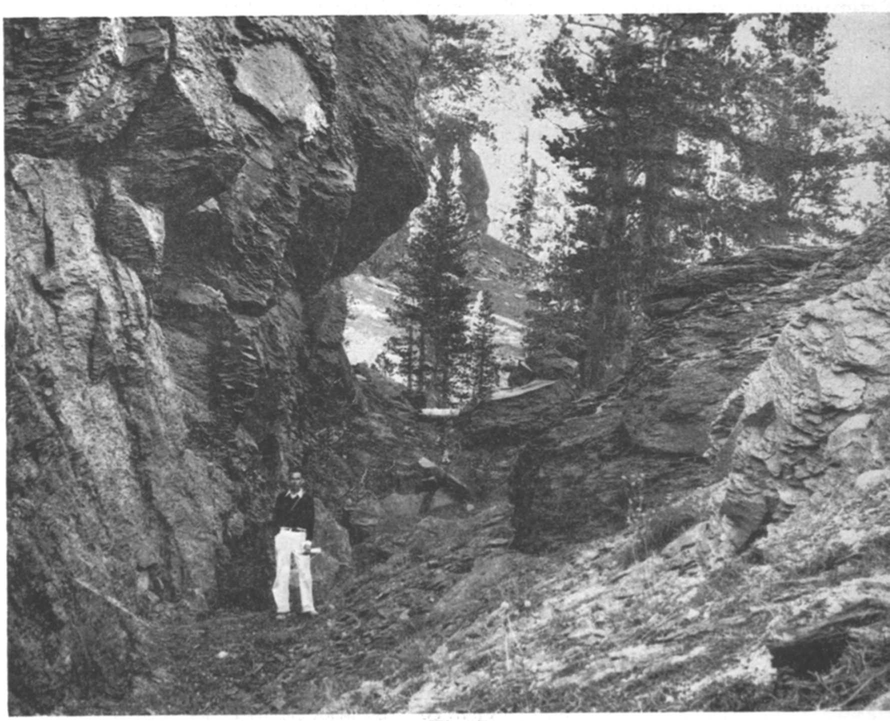


Fig. 7

Figs. 5, 6, and 7. Break "A" points in the vicinity of point 9 on map.

Fig. 8

Fig. 9

Figs. 8 and 9. Break in the vicinity of point 10 on map.

In general, where the feature passes through soft ground the shoulders of the trench are higher than the surrounding region.

The fresh appearance of the fracture surface, the unfilled depth of the cracks in spite of the loose nature of the pumice which covers the sloping area, the lack of significant erosion in the waterfalls, all indicate a recent origin. On the other hand, the age of the trees growing in the trenches indicates an age of at least one hundred and fifty years. We have interviewed residents in the area who had learned from eyewitnesses that the Mammoth "Earthquake Fault" existed prior to the Owens Valley earthquake of 1872 and that it was not significantly affected by this shock. Although this region must certainly have been subjected to strong earthquakes in the past, the only information is in the form of an Indian legend concerning a strong shock about 1790.

From the available observations it is not yet possible to decide whether the features are superficial, resulting from the cooling of the lava, or whether they are expressions of tectonic processes connected with the rise of the Sierra block. The linear distribution of the volcanic structures suggests the possibility of an underlying fault zone to account for the craters as well as the fractures.

Another group of "earthquake faults" is known on the islands of Mono Lake. Although their maximum depths are in excess of one hundred feet (30 m.) on Negit Island, our inspection leads us to believe that they are purely local effects of cooling of the lavas. However, there are some trenchlike features, especially one crossing Negit Island in a north–south direction, which may have an origin similar to those discussed in this paper.

Note: We have just received (March, 1939) a paper by Dr. A. Rittmann ("Die Vulkane am Myvatn," *Bull. Volcanologique*, Sér. III, Tome IV, 1938) describing a volcanic region in Iceland which exhibits features most of which are strikingly similar to those described above. His explanation (see his fig. 6) involving a combination of faulting with volcanic activity appears to be substantially the same as ours.

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